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ABSTRACT

Research across seven very different states has shown that as schools get larger, the average achievement among economically disadvantaged students declines. A traditionally strong argument against smaller schools, however, is that they are too expensive. Large consolidated schools with narrowly specialized grade spans are typically offered as necessary to save money and to meet the needs of different age groups. This paper examines whether the size-by-socioeconomic status interaction effect proves robust across alternative regression model specifications, as it did across different states. It also explores whether the equity gains associated with smaller schools are incompatible with the need to save money. Data were analyzed for 1,001 Texas high schools, including 116 single-unit schools--K-12 schools that are the only school in their district. Analysis with four different regression model specifications consistently found that increased school size was related to increases in achievement-test-score costs associated with economically disadvantaged students. School size was negatively related to expenditure per pupil, but this relationship became increasingly tenuous as size increased, and eventually savings became negligible. In addition, organizational factors, especially as manifest in the distinctive components of the single-unit school, were related to cost reduction. For those interested in balancing expenditure per pupil with achievement-based equity, the best grade-span configuration seems to be a small single-unit school. (Contains 76 references.) (SV)

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WILL THE REAL "TEXAS MIRACLE IN EDUCATION" PLEASE STAND UP?*

GRADE SPAN CONFIGURATION, ACHIEVEMENT, AND EXPENDITURE PER PUPIL

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November, 2000

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ABSTRACT

The past decade has occasioned a dramatic increase in research on relationships between school size and a variety of outcomes, including measured achievement, high school completion rates, and postsecondary enrollment rates. An interesting interaction effect which has been found in replications across seven very different states is that as school size increases, the achievement test score costs associated with economically disadvantaged students also increases. In short, as schools get larger, average achievement among low socioeconomic status students suffers. A traditionally strong argument against smaller schools, however, is that they are too expensive. Large consolidated schools with narrowly specialized grade spans are typically offered as necessary to save money and to meet the needs of different age groups. In this paper, we have two objectives. First, to determine if the size-by-socioeconomic status interaction effect proves robust across alternative regression model specifications, as it did across different states. Second, to make a tentative judgment as to whether the equity gains associated with smaller schools are incompatible with the need to save money.

WILL THE REAL "TEXAS MIRACLE IN EDUCATION" PLEASE STAND UP?

GRADE SPAN CONFIGURATION, ACHIEVEMENT, AND EXPENDITURE PER PUPIL

Educational researchers and policy makers rarely meet an issue they are willing to resolve once and for all. School size is a case in point.

Interest in school size as an explanatory factor waxes and wanes, but never dies. The effect of variability in school size on educational achievement and a variety of related outcomes remains a subject of sometimes intense, sometimes dilatory disciplined inquiry and debate.

In the study reported here, we use a Texas data set representing 1001 high schools to build on previous research, completed first in California and then replicated in six very different states. This research has, with unusual consistency, found an interesting interaction effect between socioeconomic status and school size in the production of achievement: as school size increases, school performance (aggregate achievement at the school level) decreases for economically disadvantaged students. In short, as schools get larger, those with poor children as students perform increasingly less well when achievement is the outcome measure.

RESEARCH QUESTIONS

Continuing this line of research, we will address two specific questions. First, will replication with a more adequately specified regression model find the same size-by-socioeconomic status (size-by-SES) interaction effect among the high schools in our Texas data set? Second, whatever the

merits of small schools, are large high schools with conventionally narrow grade ranges necessary to "save money," (that is, to minimize expenditures per pupil) or can cost savings occur *without* increased size?

REPLICATION THROUGH RE-SPECIFICATION

In previous analyses, the independent variables included in regression equations were limited to a measure of school size, either total number of students or number of students per grade level, a measure of SES, most often percent of students eligible for free or reduced cost lunch, and the multiplicative interaction term. On occasion ethnicity variables or class-size variables were included. The most notable exception, however, is a multi-level analysis of Georgia data which also incorporated ethnic composition and student/teacher ratio (Bickel & Howley, 2000). To improve on past research, the primary difference between the work reported herein and previous replications is a more fully specified regression model.

Therefore, we are now asking if the size-by-SES interaction effect will prove unduly sensitive to better-informed regression model specification, diminishing the credibility of the consistent results reported from previous research. In other words, does the interaction effect merely mask the influence of "the usual suspects" through inadequate model specification[1]?

FISCAL PRACTICALITY

In addition, we examine the claim that large schools with a narrow range of grades are a necessary modern organizational consequence of the need minimize expenditures. Many who have persisted in off-handedly dismissing the small-is-better research have done so in the name of fiscal practicality. Large consolidated schools, specializing in just a few grade levels, are uncritically judged as essential for economies of scale, and to meet the differing needs of different student in different grades. Holding contrary views appears a nostalgic preference for a romanticized common school ideal. (For a more balanced view, see Boex & Martinez-Vasquez, 1998).

School size *is* negatively related to expenditure per pupil. However, our analyses regarding the link between school size and expenditure per pupil go beyond the usual simplicities to include the under-researched concept of *grade span configuration*.[2]

Specifically, one hundred sixteen of the high schools in our Texas data set are single-unit schools: the only school in a typically small, typically rural district, containing all elementary and secondary grades under one roof. With expenditure per pupil as the outcome measure, multiple regression analysis shows that single-unit schools, on average, correspond to a reduction in expenditure of $1017 per pupil, a substantial saving, when compared with conventionally grade-specialized high schools. (See Table 6.)

This saving can be statistically attributed to two distinctive characteristics of single-unit schools in Texas: each is the only school in its district, and each has an unusually broad grade configuration, K-12, PreK-12, or early childhood-12 (see Table 7). We find, however, that the savings decline as such schools become larger. In other words, in Texas, small K-12 unit schools are cost effective, all else equal. They are also, as we shall see, educationally effective because, overall, such schools do tend to be small.

SCHOOL SIZE: A TIMELY ISSUE

Research on the role of school size as a determinant of school performance has a long history and has generated a voluminous literature (see, for example, Barker & Gump, 1964; Fowler, 1991; Guthrie, 1979; Khattari, Riley, & Kane, 1997; McDill, Natriello, and Pallas, 1986; Smith and DeYoung, 1988; Walberg & Walberg, 1994). As with so many commonly invoked explanatory factors in the social and behavioral sciences, research on the effects of school size has, over the years, yielded conflicting findings (Caldas, 1993; Lamdin, 1995; Rivkin, Hanushek, & Kain, 1998; Rossmiller, 1987). As a consequence, school size sometimes has been relegated to the status of an obligatory but uninteresting control variable. Not infrequently, it simply has been ignored (Barr & Dreeben, 1983; Gamoran & Dreeben, 1986; Farkas, 1996; Hanushek, 1997, 1998; Wyatt, 1996).

Uncertainty as to the import of school size has yielded state-of-the-art school effectiveness research which fails to designate size a "resource," much less a resource worthy of investigation. A recent school effectiveness review by eleven production function virtuosos, for example, devoted four of its three hundred ninety-six pages to school size (Hodges & Greenwald, 1996, p. 81; Betts,

1996, pp. 166-168). Consequences of variability in school size were, in sum, judged to be uncertain.

This assessment is simplistic and wrong according to recent studies. In fact, the Education Commission of the State (ECS) has for some time recommend smaller school size as one of the "best investments" policy makers could sponsor (Fulton, 1996). The research base on the influence of size is developing quite rapidly, and may be said to have spawned a "movement" (Fine & Somerville, 2000).

One Size Fits All

One important limitation of most literature covering school size has been failure to examine the interaction of school size with other variables (Howley, 1989; Lee & Smith, 1995; Mik & Flynn, 1996; Riordan, 1997). This deficiency tends to give rise to a one-size-fits-all point of view. Within any school, it may seem, size-related benefits accrue and size-related costs are borne equally by all students (Conant, 1959; Haller, 1992; Haller, Monk, and Tien, 1993; Hemmings, 1996). This turns out to be a very naive assumption (Bickel & Howley, 2000).

Discounting Equity

In an era of cult-of-efficiency institutional restructuring, moreover, questions as to the best size for any school are often expressed in the scientific management terms of organizational efficiency. In economists' terminology, presumed economies of scale frequently have been given pride of place (Haller, Monk, Bear, Griffith, and Moss, 1990; Purdy, 1997; Tholkes & Sederberg, 1990;). As with much contemporary educational research, equity questions have often been deemed

largely irrelevant to the school size discussion. For many, this has come to mean that bigger is better, inevitably and always (Stevenson, 1996).

Small is Better?

Recently, nevertheless, attention has been drawn to a growing body of empirical research which holds that school size is negatively associated with most measures of educational productivity. This includes measured achievement levels, dropout rates, grade retention rates, and college enrollment rates (see, for example, Bickel and McDonough, 1997; Fowler, 1995; Fulton, 1996; Mik and Flynn, 1996; Stevens and Peltier, 1995; Walberg & Walberg, 1994).

Size-by-SES Interaction Effects

In part, renewed interest in smaller schools is due to research concerning the joint or interactive, rather than independent or main, effects of school size and socioeconomic status. Specifically, interaction effects have been identified which suggest that the well known adverse consequences of socioeconomic disadvantage are tied to school size in substantively important ways.

In brief, as school size increases, the mean measured achievement of schools with less-advantaged students declines. The larger the number of less-advantaged students attending a school, the greater the decline (Bickel & Howley, 2000; Friedkin & Necochea, 1988; Howley, 1995, 1996; Huang & Howley, 1993).

In addition to helping revive interest in school size as a variable of importance in educational research, this work has begun to sensitize researchers and policy makers to equity concerns associated with school size. One-size-fits-all is no longer a unanimous judgment. Some researchers and policy makers are now asking, "Best-size-for-whom?" (Devine, 1996, Henderson & Raywid, 1994)

REPRODUCIBLE FINDINGS: A RESEARCH AGENDA

Research on size-by-SES interactions, moreover, has substantial geographic scope. The same school-level interactions have been found in California (Friedkin & Necochea, 1988), West Virginia (Howley, 1995, 1996), Alaska (Huang & Howley, 1993), Montana (Howley, 1999a), Ohio (Howley, 1999b), Georgia (Bickel, 1999a, Bickel & Howley, 2000), and Texas (Bickel, 1999b). In contrast to so much research which has yielded initially interesting findings, the likelihood that additional replications will yield sharply conflicting results has been substantially reduced.

Texas High School Data for 1996-97

By way of continuing this line of investigation, we use a data set consisting of 1001 Texas high schools. This represents 83.6 percent of all high schools in the state for academic year 1996-97. The 196 excluded schools are those for which values were not available for one or more of the variables used in our analyses (Bickel, 1999b)

Independent Variables

As already explained, previous research on this issue has been marked by simplified regression model specification. In large part, this parsimonious approach derives from the fact that proper specification for research on school size or any other correlate of achievement is substantively uncertain and theoretically thin. The usual suspects are SES and ethnicity variables, but a host of other variables have often been included in production function models. The debate continues (cf. Greenwald, Hedges, & Laine, 1996; Hanushek, 1996; Hedges, 1996).

In absence of a resolution to this debate, the independent variables included in Table 1, however, seem appropriate. They reflect the ethnic, linguistic, and socioeconomic diversity of the state's high school students (PCTBLACK, PCTHISP, PCTLEP, PCTPOOR), they show substantial variability in Texas high schools' organizational characteristics and resources, including size (SIZE, S/TRATIO, EPP, PCTINST, UNIT, LEVELS, HIGHSKLS); and they manifest pertinent variability in curricular composition (PCTTECH, PCTSPECL, PCTGIFT).

Inclusion of student/teacher ratio (S/TRATIO), a useful proxy for class size, among the added independent variables enables us to address questions as to whether small classes in large schools diminish the adverse consequences of bigness. As it turns out, they do not. This result is consistent with tests of the hypothesis in ancillary analyses provided in two of the previous studies (Howley, 1999a, 1999b).

TABLE 1 ABOUT HERE

Dependent Variables: Measures of Achievement

In Tables 3, 4, and 5, the dependent variables are taken from the mandatory Texas Assessment of Academic Skills (TAAS) end-of-grade battery, used on a limited basis since the Fall of 1990, and fully implemented in 1994. The tests are criterion-referenced measures of attainment in reading, math, and writing, administered to tenth graders throughout the state, and used to evaluate the performance of students and, by implication, the effectiveness of schools and school districts in promoting measured achievement. Measures of internal consistency for the TAAS are reported to range from .80 to .90 (Texas Education Agency, 2000). (For critical discussions of the use and interpretation of TAAS, see Clopton, Bishop, & Klein ,1997; Haney, 2000; and Klein, Hamilton, McMaffery, & Stecher, 2000).

Dependent Variables: Expenditure Per Pupil

In Tables 6 and 7, expenditure per pupil is the dependent variable, and measured achievement is used for purposes of statistical control rather than as an outcome measure. Since scores for R10, M10, and W10 are closely correlated, use of all three in the same equation produces multicollinearity, with Condition Indices well above thirty (Gujurati, 1995: 338).

To remedy this, we have created a summary achievement measure, COMPOSITE, which is the sum of the Z scores of R10, M10, and W10. All bivariate correlations between COMPOSITE and its three constituents exceed .935.

We have also found that the relationship between SIZE and EPP is curvilinear, but that the relationship can be linearized using natural logarithms of SIZE. Use of this transformation is discussed further in the next section.

Descriptive Statistics

Table 2 shows us that the mean value for SIZE, number of students, is 877.19. The size of the standard deviation, 849.88, indicates that SIZE manifests a good deal of variability, with a coefficient of variation of 103.2 percent.

While SIZE has a positive skew, the skew is not so extreme that the variable warrants logarithmic or other transformation (Fox, 1997: 64-68). In fact, using the Studentized range test for normality, SIZE more closely approximates a normal distribution when non-transformed values are used (see Kanji, 1993: 65). Therefore, actual SIZE values are used in the analyses with achievement tests as outcome measures, reported in Tables 3, 4, and 5.

However, the relationship between SIZE and EPP is curvilinear, concave and sloping downward for the smallest values of school size, almost perfectly straight with a modest downward

slope for SIZE values between 220 and 550, almost perfectly straight with a diminished downward slope between size values 550 and 1800, then sloping still less, and eventually becoming level for SIZE values of more than 3200 students. This is similar to the curvilinear relationship between high school size and cost discovered by Stiefel, Berne, Iatarola, & Fruchter (2000) in their New York City data.

We have linearized the relationship between SIZE and EPP in our Texas data by taking natural logarithms of SIZE for the analyses reported in Tables 6 and 7.

TABLE 2 ABOUT HERE

Means and standard deviations for PCTBLAK, PCTLEP and HIGHSKLS are reported in Table 2 before the variables were logged. Since, however, each has a sharp positive skew, with most of the observations confined to a very narrow range of data on the left side of the distribution, the variability of each is tightly constrained. Taking natural logarithms spreads each distribution, making it more informative (Fox, 1997: 64-68).

It is also worth noting that the standard deviations for the R10, M10, and W10 achievement tests are small: 2.30, 4.08, 1.80. Coefficients of variation are similarly small, 5.9, 9.0 percent, and 5.5 percent.

Regression Results: A Robust Interaction Effect

Tables 3, 4, and 5 provide results of regression analyses using TAAS reading, math, and writing scores as dependent variables. The most interesting finding for present purposes is that the size-by-SES interaction effect is statistically significant and negative in each instance. This interaction , in each case, is, in fact, the most influential variable after SES and the ethnicity variables (the influence of which varies across subject areas). As school size increases, the cost to school performance of schools serving economically less-advantaged students increases, as well. This, of course, was the finding in all previous replications.

TABLE 3 ABOUT HERE

TABLE 4 ABOUT HERE

TABLE 5 ABOUT HERE

Clearly, the interaction effect involving school size and the percentage of students who are poor is robust and strong in the presence of regression model re-specification. This adds credibility to the repeatedly replicated finding that smaller schools diminish the achievement disadvantages associated with being poor. Larger schools, by contrast, exaggerate these disadvantages.

Effect Size

As with previous research on size-by-SES interactions, we have computed effect sizes by using partial derivatives. This is done by differentiating the regression equations in Tables 3 through 5 with respect to SIZE (expressed in thousand-student units), while treating the other independent variables as constants (Purcell and Varberg, 1984: 308-309 and 636-639). Statistically nonsignificant coefficients are set equal to zero.

The results, reported at the bottom of each table, are the average achievement decrements, in test score points and standard deviation (S.D.) units, which come with each quartile increment in PCTPOOR. In each instance, we see that there are mean achievement test score costs associated with economically disadvantaged students, and these costs increase as the percentage of less-advantaged students increases.

The substantial nature of the achievement costs becomes clearer when we recall that the standard deviations and coefficients of variation for R10, M10, and W10 are small. Again, this replication, based on informed regression model re-specification, makes clear that the size-by-SES interactions are robust and strong.

CAN COSTS DECLINE WITHOUT INCREASING SIZE?

In spite of the consistently strong findings about school performance, small schools with a broad range of grade levels seem to many—if not most—observers singularly anachronistic. The move toward ever-larger, ever-more grade specialized schools, is proceeding apace (Lyons, 1999; Funk and Bailey, 1999; Boex and Martinez-Vasquez, 1998). One of the coauthors recently received a query from a former student about whether any research addressed the greater effectiveness of a K-3 versus a K-5 school. The answer, not surprisingly, is "no." This study, however, together with several other studies, attempts to raise the issue of grade span configuration more systematically (e.g., Franklin & Glascock, 1998; Howley & Harmon, 2000a; Wihry, Coladarci, & Meadow, 1992; DeYoung, Howley, & Theobald, 1995). In general, the present analysis finds that restricting the grade span of a school *increases* costs. That is, given a level of school performance, the school with a broader grade span will provide that level of performance at lower cost (all else equal).

We make these analyses because, *administrators and policy makers* deal with fiscal constraints that render findings about the educational benefits of small size seem impractical. For them, cost remains a primary consideration. For instance, rural superintendents who operated small high schools (enrolling fewer than 400 students) recently cited fiscal constraints as the *primary* threat to the continued existence of such schools (Howley & Harmon, 2000b). Departure from the large, grade-specialized mode in pursuit of equity appears to many administrators to be "a luxury they cannot afford" (Keller, 2000). Findings reported here should help administrators and policy makers revise commonly held views about the fiscal practicality of operating small high schools.

Multiple Regression Analysis: Expenditure Per Pupil

In the regression analysis reported in Table 6, the dependent variable is expenditure per pupil. The independent variables are otherwise the same as with Tables 3, 4, and 5, except that the size-by-SES interaction term has been deleted as irrelevant to this analysis (since the theory links the interaction to school performance, which is not the dependent variable in these analyses), and the three achievement test scores are now used for purposes of statistical control, combined in the COMPOSITE variable.

In addition, an independent variable (not shown in the tables) has been added to control for grade level differences in expenditure per pupil. Without this control variable, the fact that lower grades have lower average EPP could lead to *exaggerated* results favoring cost reductions for schools with the broadest range of grades. This weighting variable was created by multiplying the number of students at each grade level by the mean EPP at each grade level, summing across the grades included in a school, then dividing by school size.

Finally, a multiplicative interaction term created using UNIT and SIZE (with SIZE logged and centered, see Cronbach, 1987) has been added. Given statistically significant coefficients for these two variables, a UNIT-by-SIZE interaction term will enable us to determine if the relationship between SIZE and EPP varies from single-unit schools to conventional high schools.

TABLE 6 ABOUT HERE

Regression Results: Anticipated and Unanticipated Findings

Not surprisingly, school size (SIZE) has a statistically significant and negative relationship to expenditure per pupil. The same is true of student-teacher ratio (S/TRATIO), the variable exercising the greatest influence on expenditure per pupil.

Less predictably, notice the negative, statistically significant regression coefficient corresponding to UNIT. According to these results, a single-unit school is associated with an average reduction in expenditure-per-pupil of just over $1017. Other things being equal (that is, with the full complement of controls in place), having only one school, covering all grades in a district, represents *substantial* dollar savings.

The multiplicative interaction term, UNIT-by-SIZE, however, also has a negative and statistically significant coefficient. This interaction indicates that the net influence of *increases* in school size provides *more substantial cost reductions* for single-unit schools than for conventional schools.

Reduced Costs Without Increased Size?

The results reported in Table 6 affirm the conventional wisdom that size is negatively related to expenditure per pupil, for both single-unit schools and conventional high schools. The relationship, however, is more complex than commonly acknowledged. Why, for example, after controlling for size and a reasonable complement of other factors, should single-unit schools be associated with substantial savings in expenditure per pupil? Furthermore, why should increases in size yield greater cost reductions for single-unit schools than for conventional grade-specialized schools? We seek possible answers to such questions in the organizational distinctiveness of single-unit schools as defined in this study.

Single-Unit Schools: Organizational Distinctiveness

Organizationally, the characteristics that conspicuously set these single-unit schools apart are number of grade levels, and the fact that, in this data set, each is the only school in its district.[3] Seventy-five percent of the high schools in our data set have four or fewer grades (LEVELS). Single-unit schools, however, with K-12, PreK-12, or early childhood-12 configurations, have thirteen, fourteen, or fifteen grade levels.

Similarly, the mean of the variable HIGHSKLS (before logging) tells us that the average number of high schools per district is nearly three, while a single-unit school is the only school of any kind in its district.

Single-Unit Distinctiveness and Expenditure Per Pupil

In an effort to explain cost savings associated with single-unit schools, therefore, in Table 7 we have added two additional independent variables, representing the distinctive characteristics of single-unit schools. Since LEVELS is very closely correlated with UNIT (r=.965), the UNIT variable has been deleted, replaced by the organizational components of single-unit schools (i.e., LEVELS and HIGHSKLS). We construe the new independent variables as essential components of the global, complex variable UNIT (Rosenberg, 1968, pp. 40-52). In effect, we are trying to identify the specific characteristics of UNIT that may account for its unexpected relationship with expenditure-per-pupil (EPP). These characteristics, of course, may also be associated with reduced costs in conventional high schools.

We have also created a multiplicative interaction term with SIZE and each of the components of UNIT. Thus, we are also adding to the regression equation LEVELS-by-SIZE and HIGHSKLS-by-SIZE, with all variables used in creating the interaction terms centered (Cronbach, 1987).

TABLE 7 ABOUT HERE

LEVELS, HIGHSKLS, and Expenditure Per Pupil

The results are instructive. Predictably, as with Table 6, the coefficients corresponding to SIZE and S/TRATIO are negative and statistically significant. This holds in spite of the fact that SIZE and S/TRATIO are substantially correlated (r=.736), thereby reducing statistical power. However, the variance inflation factors for each, though the largest for the equation, are well within acceptable limits, 4.870 and 4.131 (Chatterjee, Hadi, & Price, 2000, pp. 240-241).

Furthermore, given that LEVELS and HIGHSKLS are construed as effective components of UNIT, the following are not surprising: as the number of high schools in a district increases, expenditure per pupil also increases, averaging just over 332 dollars per school. In addition, each grade level added to a high school is associated with an average expenditure per pupil decrease of just over 98 dollars. (The distribution of high schools per district and by grade levels are reported in Table 8 and Table 9.)

TABLE 8 ABOUT HERE

TABLE 9 ABOUT HERE

Finally, the statistically significant interaction terms make clear that as SIZE increases, the increased costs associated with having more than one high school in a district are diminished; while the reduced costs associated with having more grade levels are reduced still more.

WHAT ARE WE TO MAKE OF ALL THIS?

School Size and Expenditure Per Pupil: Diminishing Returns

One way to summarize these complex results is to refer to effect sizes reported on Tables 6 and 7. For each analysis, as school size increases, the partial derivatives show savings, but progressively diminished savings. Yes, school size is negatively related to expenditure per pupil, but savings diminish with each increment in size.

School Size and Expenditure Per Pupil: Single-Unit Schools

Furthermore, with a judiciously selected complement of controls in place, single-unit schools and their defining characteristics, number of grade levels and uniqueness in their district, are associated with substantial savings in expenditure per pupil. For these organizationally distinctive schools, moreover, size contributes more to reducing costs than for conventional high schools. One related observation needs still to be underscored. Despite the *comparative* cost-advantages of increased size for single-unit schools, change in the rate of reduction in EPP as size increases slows for both K-12 schools and other schools—the slowing is simply less dramatic for other schools. The

effect sizes (based on quartile values of the variables in the partial derivative) given in Table 7 illustrate this point well.

School Size and Expenditure Per Pupil: HIGHSKLS and LEVELS

Not surprisingly, given the savings associated with single-unit schools, as the number of schools in a district increases, so does expenditure per pupil, though this additional cost is less for larger schools than for smaller schools. While this finding might suggest that building additional large, as compared to small, schools is cost-effective, readers need to recall two other facts. First, ever-larger size assures ever-diminishing returns with regard to expenditure per pupil. The law of diminishing returns to investment is definitely applicable. Furthermore, larger consolidated schools typically have conventionally narrow grade spans, and, as the number of grade levels in a school increases, expenditure per pupil is again diminished. So far as expenditure-per-pupil goes, size, grade span configuration, and district organization structure a complex playing field for minimizing costs. Most succinctly: Bigger is not always or even usually cheaper. The questions to be answered locally are: how big (when do returns to size increases yield negligible savings)? bigger for whom (poverty, ethnicity)? and bigger under what circumstances (i.e., district organization and grade span configuration)?

Diseconomies of Scale

Typically, economists attribute diseconomies of scale to problems posed by the need for coordination and control (Bidwell & Kasarda, 1975; Boex & Martinez-Vasquez, 1998 Friedman, 1990). This observation follows from different interests among organizational participants, including lack of consensus with regard to organizational objectives. The usual response is a system of personnel and procedures for supervision and monitoring: bureaucratic organization. Supervision and monitoring are costly additions to an organization, but in increasingly large organizations these additional costs are (ironically) increased by the need to coordinate and control those who supervise and monitor. Bureaucratic organization, a feature of increased organizational scale, inevitably has the effect of *complicating* organization itself.

As organizations become larger and more complicated, with ever-greater specialization among employees, departments, and levels, threats of organizational anomie and anarchy not only come into play, but are often *realized* and disorganization begins to prevail (Shedd and Bachrach, 1991). In dynamic fashion, "negative feedback loops" increase supervision and monitoring costs to unacceptably high, and ultimately counterproductive, levels. The description will sound familiar to many readers in big-city mega-districts as well as to readers of very large districts in other locales. The so-called "small schools movement" is a reform strategy to address this dilemma in metropolitan districts. Elsewhere, in rural areas and small towns, extant small high schools are often regarded as too expensive to exist, in part because analyses with adequate controls (such as appear in the present study) are so seldom undertaken or even understood as necessary. According to some observers, both policy analysts and policy makers have tended to ignore the issue of organizational scale as an

influence on school performance (Guthrie, 1979; Howley, 2000; Wasley, Fine, Gladden, Holland, King, Mosak, & Powell, 2000)

The results of this study may indicate that inclusion of all grade levels in the same setting fosters a common, perhaps strongly tacit, understanding of organizational purpose. A K-12 school, for example, includes all personnel who teach and administer in all grades in the same location. This may prevent development of the usual articulation problems that characterize relationships among elementary schools, middle schools, and high schools, diminishing the need for costly monitoring and supervision.

Similarly, if a school is the only one in its district, between-school differences in purpose and procedure cannot occur, further reducing the need for coordination and control through monitoring and supervision. When a single school with a broad range of grade levels is also *small*, the seemingly antithetical goals of saving money and promoting equity in achievement may be attained simultaneously.

This tentative account, of course, shifts our focus from schools to school districts. This is consistent with earlier Georgia research, in which we found that the achievement of less-advantaged students in large schools was diminished less if the school was in small districts. In addition, we found that the expected achievement gains of less-advantaged students in small schools were undercut in large districts (Bickel and Howley, 2000; Howley, 2000).

SIZE-BY-SES AND COST

Table 10 joins the size-by-SES and cost issues still more closely together. We use the same regression model specification employed in Table 7. Our achievement composite is now the outcome measure, and we reintroduce the size-by-SES interaction term.

TABLE 10 ABOUT HERE

Interestingly, LEVELS, the component of UNIT which was associated with reduced expenditures, is now associated with increased achievement. HIGHSKLS, the component of UNIT which was associated with increased expenditures, is now associated with decreased achievement.

In most other respects the results in Table 10 are like the results reported in Tables 3, 4, and 5. Once again, the size-by-SES interaction term is statistically significant and negative, and the effect sizes demonstrate that as school size increases, the presence of economically disadvantaged students is associated with diminished average achievement.

Most significantly, perhaps, the influence of size across the SES spectrum, from relatively affluent to impoverished, is negative, though the influence of size is most harmful in larger districts serving many poor students (effect size = -1.20, see Table 10). Even in small unit schools serving a relatively affluent community, however, data in Table 10 show that a one standard-deviation-unit increase in size (850 students, see Table 2), would depress school performance by about one-fourth

of a standard deviation.

CAUTIONARY COMMENTS

Our data set contains a large number of cases and a broad range of pertinent variables. Nevertheless, it is useful to bear in mind that Texas is a distinctive state. As such, our analysis is limited in specific ways.

Model Specification

Misleading results due to specification error are a good deal less threatening in our achievement analyses than in our analyses of expenditure per pupil. The size-by-SES interaction effect has proved robust across seven very different states, and for at least four different regression model specifications, two in this paper alone. (Compare Tables 3, 4, and 5 with Table 10. Also see Bickel & Howley, 2000; Friedkin & Necochea, 1988; Howley, 1995; Howley & Bickel, 1999; Huang & Howley, 1993).

Misleading results due to specification error are more likely in our analyses of expenditure per pupil because the variables we have found to be especially interesting, UNIT, LEVELS, and HIGHSKLS, as well as the interaction effects created with SIZE, are under-researched.

The research that has been done on these issues, moreover, does not address relationships between expenditure and variables such as UNIT, LEVELS, and HIGHSKLS (see Wihry, Coladarci,

and Meadow, 1992; Alspaugh, 1996; Howley & Harmon, 2000a; Franklin & Glascock, 1998). Therefore, though our choice of independent variables and functional forms seems reasonable, our regression model specification is necessarily tentative, and we readily acknowledge that a better-informed alternative might yield different results.

Concepts: Single-Unit School

We have defined single-unit schools as the only school in a district, including all grade levels. The performance of the component variables LEVELS and HIGHSKLS, along with interaction effects created with these variables and SIZE, suggests that there is merit to this way of construing the single-unit school and its distinctive components.

However, in the only national survey of single-unit schools, Howley & Harmon (2000a) suggest that the single-unit designation be applied to any K-12 school, whether or not it is the only school in its district. In Texas, however, each K-12, PreK-12, and early childhood-12 school is the only school in its district. In a real sense, as we have seen, Texas single-unit schools are districts as well as schools.

This account of the simultaneous realization of the supposedly competing objectives of equity and cost efficiency suggests that having more than one single-unit school in a district would diminish its attractiveness. The uniqueness-in-district that is a defining characteristic of single-unit schools in Texas is, a common feature of many K-12 schools (Howley & Harmon, 2000). But it does not characterize all single-unit schools still in existence.

Concepts: Expenditure Per Pupil

We have measured cost in terms of expenditure per pupil. Funk and Bailey (1999), however, in their Nebraska research, judged cost per graduate to be a superior measure of cost efficiency. After all, one virtue of smaller school size is a lower dropout rate.

Similarly, Stiefel, Berne, Iatarola, and Fruchter (2000) measured cost in terms of total budget per pupil and total budget per graduate. Neither measure revealed the cost inefficiencies commonly attributed to small schools.

Whatever the virtues of per-graduate measures, their calculation requires dropout data which covers all grades in the schools being analyzed (Stiefel, Berne, Iatrola, and Fruchter, 2000: 33). Twenty-five percent of our Texas high schools, however, have five or more grades, and information on dropouts is often not reported for lower grades. Our choice of the traditional expenditure per pupil measure, therefore, was dictated by the information available in our Texas data set. Its use, together with use of our grade-level-expense weighting variable (described previously), nonetheless means that the findings reported here probably represent conservative estimates of cost efficiency.

Multi-Level Analysis?

With the individual high school as the unit of analysis, an obvious strategy would be to conduct a multi-level analysis, with school districts constituting the second level. As it turns out,

however, while only 11.6 percent of the schools are of the single-unit variety, 72.6 percent of the districts operate just one high school. This yields an average within-group sample size of 1.27. High schools and districts are thoroughly confounded in the organizational structure of public secondary education in Texas, a situation common to many states.

In addition, Singer (1987) has shown that with small within-group sample sizes, and small residual intra-class correlations, standard errors of regression coefficients are diminished very little by intra-class correlation, and tests of significance are reliable. In all our analyses, deflation of standard errors due to intra-class correlation is less than two percent (Singer, 1987, pp. 224-226).

CONCLUSIONS

As with seven previous analyses, we have found that as school size increases, achievement test score costs associated with having economically disadvantaged students in schools increase, as well. This finding has now proven robust across seven states and at least four different regression model specifications. This degree of consistency is rare, indeed, in educational research.

We have also found that, while administrators and policy makers are correct in their judgment that school size is negatively related to costs, that is far from the whole story, at least with regard to expenditure per pupil. The negative relationship between size and expenditure per pupil becomes increasingly tenuous as school size increases, and eventually savings become negligible.

In addition, organizational factors, especially as manifest in the distinctive components of the

single-unit school, reveal unanticipated relationships to cost reduction. If we were designing schools solely to minimize expenditure per pupil, the best configuration might very well be a large single-unit school.

However, if we were also interested in balancing expenditure per pupil with achievement-based equity, the best configuration seems to be a small single-unit school. While decreased size would increase costs, a value of 1 on HIGHSKLS and a value of 13 to 15 on LEVELS would *substantially* diminish costs.

This study once again corroborates the manner in which SES regulates the relationship of school size to school performance. The findings have proven to be unusually robust and difficult to dismiss. This study's findings with regard to ways to reduce school costs without increasing size are more tentative, and our explanations of them are more tentative as well. Nevertheless, in the effort to resolve the aim of achievement equity with manifest fiscal constraints, it seems time to consider the issue of district organization and school grade span configuration.

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TABLE 1
Definitions of Variables

SIZE	Number of students. (Expressed in thousand-student units in Tables 3 through 5; expressed in natural logarithms of single-student units in Tables 6 and 7.)
PCTPOOR	Percentage of students eligible for free or reduced-cost lunch.
PCTBLACK	Percentage of students who are Black. (Expressed in natural logarithms.)
PCTHISP	Percentage of students who are Hispanic.
PCTLEP	Percentage of students classified as limited English proficient. (Expressed in natural logarithms.)
S/TRATIO	Student/teacher ratio.
EPP	Expenditure per pupil. (Expressed in thousand-dollar units in Tables 3 through 5.)
PCTINST	Percentage of total budget allotted for instruction.
PCTTECH	Percentage of students enrolled in a full-time career and technical education curriculum.
PCTSPECL	Percentage of students enrolled in a full-time special education program.
PCTGIFT	Percentage of students classified as gifted.
UNIT	Coded 1 for single-unit schools, and 0 otherwise.
HIGHSKLS	Number of high schools in a district. A high school is any school which includes grade 12. (Expressed in natural logarithms.)
LEVELS	Number of grade levels.
R10	Texas Assessment of Academic Skills tenth grade reading test.
M10	Texas Assessment of Academic Skills tenth grade math test.
W10	Texas Assessment of Academic Skills tenth grade writing rest.

TABLE 2
Descriptive Statistics
Means and (Standard Deviations)

SIZE	877.19
	(849.88)
PCTPOOR	36.51
	(30.93)
PCTBLACK	11.07
	(17.34)
PCTHISP	27.73
	(27.78)
PCTLEP	4.95
	(8.99)
S/TRATIO	13.24
	(3.15)
EPP	4745.67
	(1318.94)
PCTINST	69.92
	(7.34)
PCTTECH	56.12
	(20.59)
PCTSPECL	13.54
	(6.08)
PCTGIFT	9.02
	(7.07)
UNIT	0.12
	(0.32)
HIGHSKLS	2.96
	(5.12)
LEVELS	5.34
	(3.11)
R10	39.17
	(2.30)
M10	45.51
	(4.08)
W10	32.88
	(1.80)

N=1001

TABLE 3
TAAS Reading Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.177
	(.065)
PCTPOOR	-0.040***
	(-.367)
PCTBLACK!	-0.253***
	(-.142)
PCTHISP	-0.010**
	(-.123)
PCTLEP!	-0.268**
	(-.117)
S/TRATIO	- 0.008
	(-.011)
EPP	0.027
	(.015)
PCTINST	0.007
	(.022)
UNIT	0.733**
	(.102)
PCTTECH	0.004
	(.040)
PCTSPECL	0.047**
	(-.123)
PCTGIFT	0.038**
	(.118)
SIZE-by-SES	-0.035**
	(-.143)
Adjusted R-Squared	40.3%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms

Partial Derivative = -0.035(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-0.76	21.6%
(-0.33)	
-1.14	32.5%
(-0.50)	
-1.73	49.5%
(-0.75)	
-3.50	100.0%
(-1.52)	

TABLE 4
TAAS Math Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.019
	(.040)
PCTPOOR	-0.062***
	(-.318)
PCTBLACK!	-0.631***
	(-.200)
PCTHISP	-0.022**
	(-.152)
PCTLEP!	0.010
	(.002)
S/TRATIO	-0.146**
	(-.113)
EPP	-0.149
	(-.048)
PCTINST	0.007
	(.013)
UNIT	0.611
	(.048)
PCTTECH	0.005
	(.024)
PCTSPECL	-0.064**
	(-.095)
PCTGIFT	0.052**
	(.090)
SIZE-by-SES	-0.060**
	(-.144)
Adjusted R-Squared	30.5%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = -0.060(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-1.30	21.6%
(-0.32)	
-1.95	32.5%
(-0.48)	
-2.97	49.5%
(-0.73)	
-6.00	100.0%
(-1.47)	

TABLE 5
TAAS Writing Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.052
	(.025)
PCTPOOR	-0.031***
	(-.366)
PCTBLACK!	-0.183***
	(-.132)
PCTHISP	-0.002
	(-.037)
PCTLEP!	-0.310***
	(-.173)
S/TRATIO	-0.041
	(-.072)
EPP	-0.007
	(-.006)
PCTINST	0.007
	(.027)
UNIT	0.505**
	(.090)
PCTTECH	-0.001
	(-.010)
PCTSPECL	-0.036***
	(-.123)
PCTGIFT	0.027**
	(.105)
SIZE-by-SES	-0.033***
	(-.171)
Adjusted R-Squared	40.3%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = -0.033(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-0.71	21.6%
(-0.40)	
-1.07	32.5%
(-0.60)	
-1.63	49.5%
(-0.91)	
-3.30	100.0%
(-1.84)	

TABLE 6
Unit Schools and Expenditure Per Pupil!!
Unstandardized and (Standardized) Coefficients

SIZE!	-254.415***
	(-.199)
PCTPOOR	-4.158
	(-.066)
PCTBLACK!	81.239**
	(.080)
PCTHISP	5.668**
	(.119)
PCTLEP!	37.920
	(.029)
S/TRATIO	-284.614***
	(-.680)
PCTINST	-35.422***
	(-.199)
PCTTECH	-2.923
	(-.046)
PCTSPECL	1.291
	(.006)
PCTGIFT	4.823
	(.026)
COMPOSITE	-3.551
	(-.008)
UNIT	-1017.607***
	(-.247)
UNIT-by-SIZE	-730.195***
	(-.172)
Adjusted R-Squared	51.4%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.
!! Weighted for differences in mean EPP by grade level.

Partial Derivative = -254.415(1/SIZE) - 730.195(UNIT)(1/SIZE)

Effect Size (Dollars)		SIZE (Quartiles)
UNIT=1	UNIT=0	
-4.48	-1.16	220
-2.20	-0.57	447
-0.67	-0.17	1459
-0.22	-0.06	4434

TABLE 7
One High School, Grade Levels, and Expenditure Per Pupil!!
Unstandardized and (Standardized) Coefficients

SIZE!	-290.519***
	(-.227)
PCTPOOR	-2.927
	(-.046)
PCTBLACK!	35.476
	(.035)
PCTHISP	4.160*
	(.088)
PCTLEP!	23.216
	(.018)
S/TRATIO	-314.462***
	(-.751)
PCTINST	-34.101***
	(-.191)
PCTTECH	-3.365
	(-.053)
PCTSPECL	1.318
	(.006)
PCTGIFT	0.646
	(.003)
COMPOSITE	8.725
	(.019)
HIGHSKLS!	332.023***
	(.223)
LEVELS	-98.358**
	(-.232)
HIGHSKLS-by-SIZE	-114.038*
	(-.076)
LEVELS-by-SIZE	-48.445**
	(-.108)
Adjusted R-Squared	52.8%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.
!! Weighted for differences in mean EPP by grade level.

Partial Derivative = - 290.519(1/SIZE)
- 114.038(HIGHSKLS)(1/SIZE) - 48.445(LEVELS)(1/SIZE)

Effect Size (Dollars)	SIZE (Quartiles)	HIGHSKLS (Quartiles)	LEVELS (Quartiles)
-2.20	220	0	4
-1.08	447	0	4
-0.41	1459	0.69	6
-0.31	4434	3.26	15

TABLE 8
High Schools Per District

1	2	3	4	5	6	8	10	12	21	26
92.49% (727)	3.69% (29)	1.14% (9)	1.27% (10)	0.76% (6)	0.51% (4)	0.25% (2)	0.25% (2)	0.13% (1)	0.13% (1)	0.13% (1)

TABLE 9
Grade Levels Per High School

2	3	4	5	6	7	9	12	13	14	15
0.50% (5)	1.80% (18)	72.43% (725)	0.80% (8)	11.09% (111)	1.70% (17)	0.09% (1)	0.09% (1)	5.79% (58)	3.70% (37)	2.00% (20)

TABLE 10
Composite Achievement
Unstandardized and (Standardized) Coefficients

SIZE!	0.218
	(.079)
PCTPOOR	-0.054***
	(-.403)
PCTBLACK!	-0.270***
	(-.123)
PCTHISP	-0.008
	(-.081)
PCTLEP!	-0.255*
	(-.090)
S/TRATIO	0.017
	(.019)
PCTINST	0.004
	(.011)
PCTTECH	0.001
	(.009)
PCTSPECL	-0.056***
	(-.121)
PCTGIFT	0.051***
	(.130)
HIGHSKLS!	-0.946***
	(-.297)
LEVELS	0.130**
	(.142)
HIGHSKLS-by-SIZE	0.534***
	(.166)
LEVELS-by-SIZE	0.050
	(.051)
SIZE-by-SES	-0.034*
	(-.116)
Adjusted R-Squared	42.7%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = 0.534(HIGHSKLS)(1/SIZE) - 0.034PCTPOOR)

Effect Size Points (S.D. Units)	SIZE (Quartiles)	HIGHSKLS (Quartiles)	PCTPOOR (Quartiles)
-0.73 (-0.26)	220	0	21.6
-1.10 (-0.39)	447	0	32.5
-1.68 (-0.59)	1459	0.69	49.5
-3.39 (-1.20)	4434	3.26	100.0

Notes

[1] Evidence from a related study conducted with Alaska data (Huang & Howley, 1993) , which included several blocks of contextual, student background, and school-level process variables, suggests that the interaction effect may be robust. Using individual-level data, the interaction term remained significant after entry of all blocks of relevant data.

[2] The controlled vocabulary of the ERIC database includes "grade span configuration" as an "identifier," but not as a "descriptor." Descriptors are main indexing terms and are adopted after a lengthy and formal deliberation, identifiers may be coined by any ERIC clearinghouse at any time and serve as p,roto-descriptors. As of this writing, "grade span configuration," added in the early 1990s, had been used to index just 4 items.

[3] In a survey of all unit schools nationally, two-thirds of respondings superintendents indicated that their school district operated a single school—the K-12 unit school in question. All responding Texas superintendents indicated their schools were in this category. Among the other states, most seemed to maintain unit schools principally on this model. States where unit schools were more freuqently part of multi-school districts included Alabama, Alaska, Louisiana, and Mississippi (Howley & Harmon, 2000a).